Factors influencing credentialing of interventionists in the CREST-2 trial

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ABSTRACT

Background: The Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2) is a pair of randomized trials assessing the relative efficacy of carotid revascularization in the setting of intensive medical management (IMM) in patients with asymptomatic high-grade atherosclerotic stenosis. One of the trials assesses IMM with or without carotid artery stenting (CAS). Given the low risk of stroke in nonrevascularized patients receiving IMM, it is essential that there be low periprocedural risk of stroke for CAS if it is to show incremental benefit. Thus, credentialing of interventionists to ensure excellence is vital. This analysis describes the protocol-driven approach to credentialing of CAS interventionists for CREST-2 and its outcomes.

Methods: To be eligible to perform stenting in CREST-2, interventionists needed to be credentialed on the basis of a detailed Interventional Management Committee (IMC) review of data from their last 25 consecutive cases during the past 24 months along with self-reported lifetime experience case numbers. When necessary, additional prospective cases performed in a companion registry were requested after webinar training. Here we review the IMC experience from the first formal meeting on March 21, 2014 through October 14, 2017.

Results: The IMC had 102 meetings, and 8311 cases submitted by 334 interventionists were evaluated. Most were either cardiologists or vascular surgeons, although no single specialty made up the majority of applicants. The median total experience was 130 cases (interquartile range [IQR], 75-266; range, 25-2500). Only 9% (30/334) of interventionists were approved at initial review; approval increased to 46% (153/334) after submission of new cases with added training and re-review. The median self-reported lifetime case experience for those approved was 211.5 (IQR, 100-350), and the median number of cases submitted for review was 30 (IQR, 27-35). The number of CAS procedures performed per month (case rate) was the only factor associated with approval during the initial cycle of review ($P < .00001$).

Conclusions: Identification of interventionists who were deemed sufficiently skilled for CREST-2 has required substantial oversight and a controlled system to judge current skill level that controls for specialty-based practice variability, procedural experience, and periprocedural outcomes. High-volume interventionists, particularly those with more recent experience, were more likely to be approved to participate in CREST-2. Primary approval was not affected by operator specialty. (J Vasc Surg 2020;71:854-61.)

Keywords: Carotid stent; Clinical trial; Carotid atherosclerosis; Stroke prevention

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In any prospective randomized trial comparing the efficacy of therapeutic strategies, it is necessary to optimize the therapies to reflect state-of-the-art management practices. The Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2) is a pair of randomized trials assessing the incremental efficacy of carotid revascularization in the setting of intensive medical management (IMM) in patients with asymptomatic high-grade atherosclerotic stenosis. IMM of asymptomatic carotid stenosis is the unproven strategy being compared with carotid revascularization.[1] Medical management of all patients in the study has incorporated unprecedented rigor in comprehensively optimizing risk factor and pharmacologic care. The revascularization arms of the two trials are similarly designed to offer the safest and most efficacious procedural outcomes using carotid artery stenting (CAS) and carotid endarterectomy (CEA).

The CREST-2 Surgical Management Committee credentials CEA operators. This process addresses a stable and efficacious operation with >60 years of experience. As demonstrated by the Carotid Revascularization Endarterectomy versus Stenting Trial (CREST), this credentialing process proved to be effective in producing low periprocedural event rates and offers validation of the credentialing process.[2-4] The CREST-2 Interventional Management Committee (IMC) was tasked to identify interventionists capable of achieving similar outcomes in the CAS arm of the trial. Stenting is a rapidly evolving intervention, with evolving technologies, techniques, and understanding of patient selection. The procedure is notable for a multidisciplinary cohort of interventionists with varying professional backgrounds. Interventional cardiologists, vascular surgeons, neuroradiologists, neurosurgeons, and interventional neurologists have adopted the procedure through disparate training pathways. Accordingly, training and experience criteria for credentialing differ.[5] Furthermore, the reimbursement environment has significantly limited interventionists' experience.

The study population in CREST-2 represents a low-risk cohort of asymptomatic patients with suitable alternatives to CAS, including IMM and, in many instances, CEA. In consideration of trial credibility and ethics, it is essential that only interventionists capable of the safest outcomes be credentialed. Furthermore, should the trial confirm the efficacy of CAS, it is important that there be wide dissemination of the protocol used to achieve these results, including the credentialing of safe interventionists, if the results are to be properly translated into standard practice. In addition, for the trial to be applicable to the community at large, the IMC had to identify a sufficiently large cohort of interventionists at the >120 medical centers participating in the study. This paper describes the protocol-driven approach, its outcomes, and factors influencing the credentialing of CAS interventionists for CREST-2.

ARTICLE HIGHLIGHTS

- **Type of Research:** Multicenter longitudinal analysis of retrospective case submissions and prospectively collected Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2) Registry data
- **Key Findings:** The CREST-2 Interventional Management Committee reviewed 8311 carotid artery stenting (CAS) submissions by 334 interventionists from 120 centers. During 3.5 years, the credentialing review process resulted in approval of 46% of interventionists into the stenting arm of CREST-2. The median number of cases submitted by the approved interventionists was 30, with a median lifetime CAS experience of 211.5 cases.
- **Take Home Message:** High CAS case rate per month was the only factor associated with approval to randomize in the trial during the initial review. Primary approval was not affected by operator specialty.

METHODS

Committee membership and organization. The CREST-2 IMC is composed of representatives of the multiple medical disciplines performing CAS. Membership was set to best represent the current distribution of subspecialties performing the procedure in North America and the distribution of well-performing sites in the prior CREST. These subspecialties included interventional cardiology (n = 4), vascular surgery (n = 2), interventional neuroradiology (n = 2), neurosurgery (n = 2), interventional neurology (n = 1), and interventional radiology (n = 1). The Committee also included the CREST-2 principal investigator and co-principal investigators representing neurology (n = 2) and vascular surgery (n = 1). The IMC initially met weekly and subsequently biweekly to review credentialing applications. CREST-2 staff members maintained minutes of all meetings and all submissions, and recommendations and approvals were tabulated prospectively.

Members of the IMC participated in establishing the CREST-2 Registry (C2R).[6] This registry was used to facilitate conditionally approved interventionists' gaining additional experience so that they could be considered for approval in subsequent reviews. Early in the process, it became apparent that the reimbursement environment had dramatically reduced the practice of CAS. Since the completion of several large carotid registry trials and CREST, stenting case volume in many institutions had diminished to a level inconsistent with the opportunity for safe and effective practice. The C2R was initiated with joint approval and collaboration of the National Institutes of Health-National Institute of Neurological

Disorders and Stroke, the Centers for Medicare and Medicaid Services (CMS), the CREST-2 Executive Committee, the Society for Vascular Surgery, and the American College of Cardiology to facilitate CAS in prospective CREST-2 trial sites. The IMC defined minimum standards for interventionist participation in C2R. Registry participation was then used to measure case volume, frequency, adherence to protocol-driven provisions for appropriate case selection, technique, and outcomes.

Credentialing protocol. For the IMC to review an interventionist for participation in either the CREST-2 trial or C2R, the prospective interventionist was required to submit the most recent 25 consecutive cases as primary operator, whether in training or after training. The IMC preferred interventionists who had completed their last 25 cases within the preceding 12 to 24 months. The interventionist was also required to have a self-reported lifetime experience in excess of 100 cases. The Committee also took note of technique, outcomes, and formal training at high-volume programs. For an interventionist recently completing training, an experience of 20 cases in addition to an ongoing acceptable current volume of cases, defined as an average of 1 or 2 per month, was considered acceptable. Lower volume interventionists (defined as those without 25 cases within the preceding 12 months) who were not able to be credentialed but had a lifetime case volume of at least 100 CAS procedures including 12 performed in the past 2 years and who demonstrated evidence of appropriate technique and outcomes were offered conditional approval. Participation in C2R was offered to interventionists who received conditional approval, with the goal of measuring and supplementing ongoing current experience, technique, and outcomes.

The initial submission required tabulation of dates of procedures, demographics, symptomatic status, and outcomes for stroke and death. This information was accompanied by submission of procedure report and discharge summary details. Committee members scrutinized these details before teleconference discussion and submission. The primary mission of the review process was to identify high-quality transfemoral CAS operators (transcarotid revascularization is not included in CREST-2). A consensus decision was made to decide one of the following: not to approve the interventionist for CREST-2 randomization or C2R; to approve the interventionist for C2R only; or to approve the interventionist for CREST-2 randomization and C2R. New applications were not entertained from practitioners who had been rejected. To approve an interventionist for C2R only, the interventionist had to practice at a site that was currently or anticipated to be a CREST-2 site, and the IMC had to believe that the interventionist had the potential to progress to be a CREST-2 investigator with additional cases in C2R. The IMC could recommend up to 20 additional cases in C2R. The IMC reviewed case angiograms, and feedback on case selection and technique was provided to all by letter and telephone. If credentialed, there was continued scrutiny for outcomes and images, and procedural notes for the first three CAS cases enrolled in CREST-2 by an interventionist were reviewed by the IMC. The IMC was also available to answer any questions that interventionists may have during the selection, care, treatment, or follow-up of any CAS patient.

Webinar training. The Committee required that all interventionists approved to participate in the randomized trial or the registry participate in a 1-hour training webinar. This training session addressed the unique protocol-driven case selection criteria and procedural techniques to be used in CREST-2. The webinar was necessary to refocus interventionists on updated, "state-of-the-art" anatomic selection criteria, mandatory for low stroke risk outcomes in the asymptomatic participants in CREST-2. The webinar, in particular, focused on the decision for revascularization in the asymptomatic elderly patient and emphasized the care and anatomic considerations important in this group. It also addressed what the Committee, by consensus, considered was optimal technique able to produce a periprocedural stroke risk in asymptomatic patients of approximately 1%.

Additional case review. Interventionists not approved to enroll in the trial but approved to enroll in C2R (ie, conditionally approved) were asked to perform additional cases in the registry and to provide detailed data sheets on standard bifurcation carotid stent cases (eg, not vertebral, subclavian, common carotid, or intracranial). To ensure the submission of representative data, once C2R was active at the site, all carotid stent cases at the center were to be entered into the registry. Each case listed had to be accompanied by stenting angiography and procedure and discharge summaries for each case. Cases performed for subthreshold stenoses or not performed using standard protocol were disqualified and additional cases requested.

Statistical analysis. Predictors of approval at first review, at second review, and at any review were assessed. These included percentage of asymptomatic cases submitted, subspecialty of the interventionist, case rate (defined as number of cases performed divided by the time between oldest and most recent case submitted), and number of periprocedural stroke events. Logistic regression was used to assess the association of these factors with approval at the given time points.

Institutional Review Board or Ethics Committee approval is obtained from all study sites, and written informed consent is obtained from all CREST-2 trial participants. Consistent with the Transparency and Openness

Table I. Characteristics of the first 334 interventionists reviewed by the Interventional Management Committee (IMC) for consideration to participate in the stenting trial of the Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2)

Subspecialty	No. (%)
Cardiology	127 (38.0)
Vascular surgery	78 (23.4)
Neurosurgery	51 (15.3)
Radiology	45 (13.5)
Interventional radiology	7 (2.1)
Neuroradiology	38 (11.4)
Neurology	33 (9.9)
Asymptomatic case rate	**%**
Proportion of asymptomatic cases submitted for review by interventionists, mean (SD)	50.3 (25.9)
Interventionists with case mix of <50% asymptomatic cases	46.6
Interventionists with case mix of >50% asymptomatic cases	53.4
No. of 30-day stroke complications	
Zero	68.2
1	24.2
2+	7.6
Case rate, No./y	
Mean (SD)	12.8 (12.4)
Median (range)	9.3 (0.58-102.6)

SD, Standard deviation.

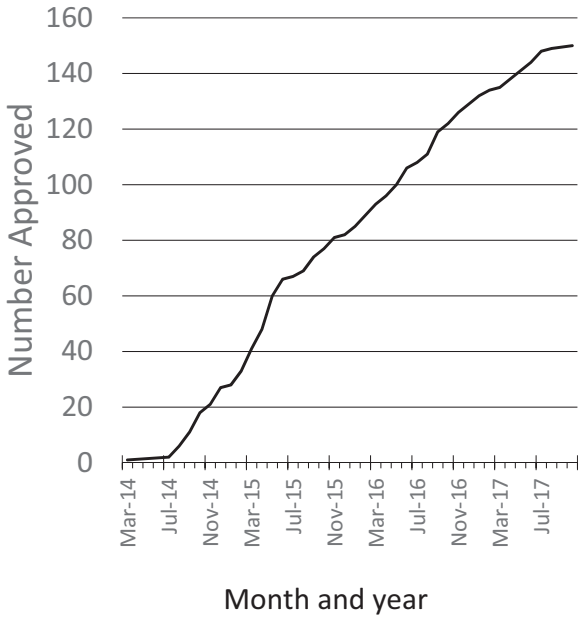

Fig. The cumulative number of interventionists approved to enroll patients in the stenting trial of the Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2).

guidelines of the Center for Open Science, data supporting the findings of the study are available on written request from the corresponding author (B.K.L.).

RESULTS

The first formal review of an interventionist occurred on March 21, 2014, and this report includes reviews through October 14, 2017. The IMC conducted 102 meetings and evaluated 334 interventionists (Table I). Most of the evaluated interventionists were either cardiologists or vascular surgeons, although no single specialty made up the majority of applicants (Table I). The median total experience was 130 carotid stent cases (interquartile range [IQR], 75-266; range, 25-2500 with one individual contributing 2500). There was no significant shift in the distribution of specialties over time.

A total of 8311 cases performed from August 2001 to April 2016 were submitted and reviewed by the IMC, with 4014 of the cases being symptomatic, 4118 asymptomatic, and 179 undetermined. The range of cases reviewed per interventionist was 5 to 44. Of the 330 interventionists with periprocedural follow-up data, 68% (225/330) reported no stroke events, 24% (80/330) reported one stroke event, and 8% (25/330) reported two or more. Those who were unable to provide procedural/operative notes and discharge summaries and outcome information for their cases were not credentialed. The IMC requested additional, more recent cases for review from individuals who submitted only cases from the past.

As of October 14, 2017, the IMC had approved 46% (153/334) of the interventionists who had applied. The number of approvals varied considerably from one meeting to another meeting, but during the years, the rate of approvals has declined from slightly more than four per month to slightly less than four per month (Fig). A total of 9% (30/334) of interventionists were approved at the first review, 53% (85/160) at the second review, and 78% (38/49) after the third or more reviews (Table II). The 160 interventionists who were not approved on first review submitted 1339 additional contemporary cases for subsequent re-reviews. Of the 153 interventionists approved to randomize in the trial, the median number of cases submitted for review was 30 (IQR, 27-35); 134 reported lifetime case experience, and the median number of cases was 211.5 (IQR, 100-350).

Wide variation was noted in case selection and technique during the individual review of several initial case submissions, with Committee members expressing concerns about CAS performed for patients with advanced age, adverse arch anatomy (eg, type III arches), severe vascular tortuosity, circumferential calcification, and complex vessel (eg, severe tortuosity) and lesion (eg, circumferential calcification) anatomy. Procedural errors observed included inadequate preprocedural antiplatelet therapy

Table II. Approval of interventionists to enroll patients in the stenting trial of the Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2) according to review cycle

	No. (%)
First review (n = 334)	
Approved	30 (9)
Conditionally approved[a]	246 (74)
Denied or deferred[b]	58 (17)
Second review (n = 160)	
Approved	85 (53)
Conditionally approved	42 (26)
Denied or deferred	33 (21)
Third review (n = 49)	
Approved	35 (71)
Conditionally approved	4 (8)
Denied or deferred	10 (20)
Fourth review (n = 3)	
Approved	1 (33)
Conditionally approved	1 (33)
Denied or deferred	1 (33)
Fifth review (n = 2)	
Approved	2 (100)
Conditionally approved	0 (0)
Denied or deferred	0 (0)
Any review (n = 334)	
Approved	153 (46)
Denied	181 (54)

[a]Conditionally approved is defined as operators who were approved pending submission of specified number of additional cases (range, 5-20).
[b]Denied or deferred is defined as operators who were not approved or conditionally approved because of lack of experience, low case volume, or questionable technique or the committee was awaiting documentation of experience at time of the review.

and medical management with statins, underuse and overuse of anticoagulation, excessive angiographic runs, excessive manipulation, aggressive postdilation of the stent, and prolonged embolic protection device dwell times.

At first review, the number of CAS procedures performed per month (case rate) was the only factor associated with direct approval to commence enrollment in the stent trial of CREST-2 ($P < .0001$; Table III). At second review, only the specialty of the interventionist ($P < .001$) was associated with approval. The number of pairwise comparisons implies that differences should be interpreted with caution; whereas the proportion of interventionists approved on first review did not differ by specialty, the proportion of cardiologists approved on the second review was higher than the proportion of radiologists ($P = .04$), neurosurgeons ($P = .03$), or vascular surgeons ($P < .0001$) approved. All other pairwise comparisons were nonsignificant ($P > .05$). Approval at either the first, second, or third review was associated with case rate ($P < .0001$) and specialty ($P = .0001$). Similar to approval at the second stage, the proportion of cardiologists approved at any re-review stage was higher than the proportion of neurologists ($P = .046$), neurosurgeons ($P = .009$), or vascular surgeons ($P < .0001$) approved.

DISCUSSION

We found that the IMC approved <10% of CREST-2 applicants to perform stenting on initial review, despite the fact that half of the applicants had performed 130 or more carotid stenting cases at the time of applying. The low initial approval rate is attributable to the low average number of recent cases performed, reflecting the prevailing reimbursement environment, in which CMS and third-party payers had largely stopped reimbursement for CAS procedures. This decline in reimbursed procedures contributed to low case volume at medical centers with previously substantial case volume and for interventionists with a large career experience with CAS. The reimbursement opportunity provided by the C2R was a vehicle to achieve this goal.

We found that case rate was a predictor of credentialing in the first and final rounds of review. There is good justification for IMC reviewers to have confidence in high-volume applicants. The Carotid ACCULINK/ACCUNET Post Approval Trial to Uncover Rare Events (CAPTURE 2) prospective multicenter registry with blinded outcome adjudication found a clear inverse linear relationship between 30-day death and stroke rate and number of procedures performed per physician.[7]

The CAS experience and expertise required for CREST-2 exceed those reported for previous trials (Table IV). Baseline CAS experience required varied across many of the pivotal carotid stenting trials, including Endarterectomy vs Angioplasty in Patients with Symptomatic Severe Carotid Stenosis (EVA-3S),[8] Stent-Protected Angioplasty vs Carotid Endarterectomy (SPACE),[9] International Carotid Stenting Study (ICSS),[10] CREST,[2] Asymptomatic Carotid Surgery Trial 2 (ACST-2),[11] and Asymptomatic Carotid Trial 1 (ACT-1).[12] Additional cases were requested for >90% of the CREST-2 applicants. Case angiograms were reviewed by the IMC, and feedback on case selection and technique was provided to all by letter and telephone. Such a process has not been attempted or achieved in previous trials. Differences across carotid trials in requirements for participation by interventionists may be related to expedience but could also relate to differences in interventionist communities and professional societies. Investigators, regulatory bodies, and funding agencies might also have different views on what constitutes acceptable procedural risk. Surgeons vary widely in their perception of risk and benefit in the decision to operate,[13] and something similar may be influencing those who design and execute carotid stenting trials. Previous carotid trials involving a surgical arm

Table III. Predictors of approval of a prospective interventionist to enter patients in the stenting trial of the Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2)

	Approved vs not approved, first review (n = 334)		Approved vs not approved, second review (n = 160)		Approved vs not approved, ever (n = 334)	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Subspeciality						
Cardiology	1.00 (reference)	.15	1.00 (reference)	.0009	1.00 (reference)	.0001
Radiology	0.32 (0.07-1.46)		0.38 (0.15-0.95)		0.87 (0.44-1.72)	
Neurology	0.22 (0.03-1.70)		0.66 (0.21-2.08)		0.45 (0.21-0.99)	
Neurosurgery	1.10 (0.43-2.87)		0.32 (0.11-0.91)		0.41 (0.21-0.80)	
Vascular surgery	0.38 (0.12-1.17)		0.12 (0.04-0.34)		0.26 (0.14-0.47)	
Percentage of asymptomatic cases						
≤50%	1.00 (reference)	.85	1.00 (reference)	.57	1.00 (reference)	.67
>50%	0.93 (0.43-2.00)		1.2 (0.64-2.25)		1.10 (0.71-1.70)	
No. of 30 day stroke complications						
Zero	1.00 (reference)	.23	1.00 (reference)		1.00 (reference)	.69
1	0.44 (0.15-1.31)		1.11 (0.54-2.31)	.96	0.86 (0.51-1.43)	
2+	0.35 (0.05-2.67)		1.06 (0.34-3.37)		0.74 (0.32-1.71)	
Case rate (cases/year)	1.09 (1.06-1.13)	<.0001	1.002 (0.97-1.03)	.92	1.08 (1.05-1.11)	<.0001

CI, Confidence interval; *OR*, odds ratio.

Table IV. Credentialing process for interventionists in major recent trials of carotid stenting

Trial	Interventional committee	Total stent cases	Carotid stent cases	Interventionists reviewed	Interventionists approved	Cases reviewed
EVA-3S[a]	Not stated	35 any endovascular cases (or 12 CAS)	12	Not stated	Not stated	Not stated
SPACE	No		25	Not stated	Not stated	Not stated
ICSS[b]	Not stated	50	10			
CREST	Yes	Not stated	≥35 cases with additional 5 to 20 in lead-in study[c]	427	238 (56%)	10,164
ACST-2	Yes	Not stated	25 within prior 2 years	Trial under way	Trial under way	Not stated
ACT-1	No	Not stated	25 recent cases and ≥2 cases in lead-in phase	Not stated	Not stated	Not stated
CREST-2	Yes	Not defined	>100	334	153 (46%)	8311

ACST-2, Asymptomatic Carotid Surgery Trial 2; *ACT-1*, Asymptomatic Carotid Trial; *CAS*, carotid artery stenting; *CREST*, Carotid Revascularization Endarterectomy versus Stenting Trial; *CREST-2*, Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial; *EVA-3S*, Endarterectomy vs Angioplasty in Patients with Symptomatic Severe Carotid Stenosis; *ICSS*, International Carotid Stenting Study; *SPACE*, Stent-Protected Angioplasty vs Carotid Endarterectomy.
[a]Minimal requirements were waived if carotid artery stenting was performed under the supervision of a credentialed interventionist.
[b]Minimal requirements were waived if carotid artery stenting was proctored by an outside interventionist appointed by the trial steering committee.
[c]After completing training, these interventionists proceeded with enrollment in the lead-in phase of CREST. Those with more experience (≥30 cases) performed 5 to 10 procedures in the lead-in phase, and those with less experience (<30 cases) performed 10 to 20 procedures in the lead-in phase (73 exempted because of extensive training and experience).

(Asymptomatic Carotid Atherosclerosis Study [ACAS], CREST) have implemented similar approaches to surgeon credentialing. The selection process in those trials has served to inform practicing physicians about the specific skill set and patient characteristics (beyond a simple classification into symptomatic and asymptomatic) that should guide the selection of a particular form of treatment. Investigators may have different perceptions of the extent to which outcomes are determined by the training, experience, and expertise of the interventionists.

Researchers have an ethical obligation to ensure patients' safety in any clinical trial, and in the case of carotid revascularization trials, a key component is credentialing interventionists of high skill and sufficient contemporary experience. This obligation extends beyond research into clinical practice and is widely recognized by multiple professional organizations, the result being the promulgation of standards for training and credentialing for carotid stenting.[14] Some of the earlier large randomized trials of carotid stenting failed to ensure low periprocedural risk

Table V. Carotid stenting credentialing recommendations from professional organizations (summary)

Organization	Previous experience	Procedural experience
Society of Interventional Radiology (SIR), American Society of Interventional and Therapeutic Neuroradiology (ASITN), and American Society of Neuroradiology (ASNR)	200 cervicocerebral angiograms performed under the supervision of a qualified physician and with at least 50% performed as the primary operator, or at least 100 diagnostic angiograms	25 non-carotid stent procedures, plus completion of a "hands-on" course in performance of CAS, plus performance and completion of at least 4 successful CAS procedures as principal operator under the supervision of an on-site qualified physician; or 10 CAS procedures as principal operator under the supervision of an on-site qualified physician.
Society for Vascular Surgery (SVS)	50 patients with carotid disease as the primary physician; 30 diagnostic cerebrovascular angiograms with 15 as a supervised primary operator	25 supervised CAS, at least half as primary operator
Society for Vascular Medicine and Biology (SVMB), Society for Cardiovascular Angiography and Interventions (SCAI), SVS, and American College of Cardiology (ACC)	Residency or fellowship training program in conjunction with peripheral angioplasty training that will include carotid training; or postgraduate training to perform carotid stenting. 30 angiograms, half as primary operator, in a supervised setting.	A minimum of 25 CAS procedures (half as primary operator)
Neurovascular coalition including American Academy of Neurology (AAN), AANS, ASITN, ASNR, Congress of Neurological Surgeons (CNS), AANS/CNS Cerebrovascular Section, and SIR	100 supervised cervicocerebral angiograms	The principles of training and quality assurance stated in the multisociety Quality Improvement Guidelines for the Performance of Cervical Carotid Angioplasty and Stent Placement

CAS, Carotid artery stenting.

rates.[15] The CREST-2 investigators established a review process that included webinar-based training, a companion CMS-supported registry, and a multispecialty IMC to credential interventionists.

There were few stroke events among the cases submitted for initial review by the IMC, giving rise to statistical challenges that prevent the strictly objective assessment of individual interventionists. Two-thirds of the interventions had no strokes within 30 days of stenting. As we have shown, performance of a limited series of cases does not allow reliable inclusion of high performers.[16] Credentialing in CREST-2 differs from the credentialing process in CREST, which required involvement of all operators in a lead-in registry. However, the statistical challenges associated with the lack of reliable estimates from small case series persist. Experienced interventionists were required to perform five stent cases in CREST, and less experienced interventionists were required to perform 10 stent cases.[3] Device-specific performance is not required in CREST-2. Rather than a device manufacturer-sponsored registry requirement in CREST, the CREST-2 trial has a Medicare-sponsored registry by invitation only based on review of clinical cases. Regardless, credentialing cannot be done reliably using an administrative approach (ie, a stroke rate threshold). It requires detailed review by content experts of multiple aspects of the case, beginning with patient selection.

The IMC has reviewed cases from interventionists of varying professional backgrounds. The disparate and inconsistent techniques observed by the Committee may be explained in part by the organic growth of CAS in multiple specialties with varying backgrounds and varying requirements for percutaneous intervention (Table V).[14] The CREST-2 IMC accordingly has promoted a common and rigorous protocol-driven process that we anticipate will be manifested in the final outcomes in the trial. Members of the IMC were drawn from diverse specialties to increase the credibility of a nonbiased review.

CONCLUSIONS

For a large multicenter trial to be run efficiently, a short startup phase is preferred to enhance recruitment. CREST-2 has benefited in that it leveraged the existence of a previously high-functioning team in CREST. Regrettably, the evolution of stenting in recent years required essentially reconstitution of a high-functioning team of interventionists. The pattern of credentialing was not as

front-loaded as might have been expected, given the preceding trial.[2] Our study also shows that formation or reconstitution of a high-functioning team of interventionists requires the long-term commitment of a multidisciplinary expert credentialing committee. High-volume interventionists, particularly those with more recent experience, were more likely to be approved to participate in CREST-2. Primary approval was not affected by operator specialty. A potential criticism of interventional trials like CREST-2 that include only individuals of highest skill is that the ideal results of the trial may fail to generalize after the trial. We believe that the ethical obligation to patient safety, however, trumps this concern and that it is first necessary to prove efficacy in the ideal setting before concerning oneself about generalization. Failure to prove efficacy in less than ideal settings could lead to discarding a potentially useful new intervention. Furthermore, we do believe that our report may serve to inform future interventionists about the level of experience, expertise, and patient or lesion selection required to achieve high-quality results from CAS.

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AUTHOR CONTRIBUTIONS

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